Courtesy S.C. Amstrup, NBS

Alaska

by

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Overview

The Alaskan ecoregion has many immense, mostly pristine ecosystems including marine waters and islands; the Arctic Coastal Plain and the Brooks Range; taiga forests and interior rivers; the extensive, treeless lowlands and deltas of the Yukon and Kuskokwim rivers; the rugged coastline with glacier-capped mountains and numerous fjords and tidewater glaciers; and coastal rain forests, bogs, and alpine tundra communities on numerous islands. This section highlights the status and trends of selected mammals and fish that inhabit these pristine ecosystems. Waterfowl, shorebirds, and seabirds are discussed in a separate chapter.

Caribou (*Rangifer tarandus*), muskox (*Ovibos moschatus*), and large mammalian predators such as the gray wolf (*Canis lupus*) and brown bear are vital components in the coastal plain tundra of the Arctic National Wildlife Refuge. All mammal populations on the refuge appear stable and healthy (McCabe et al., this section). Since 1989 the internationally shared (Canada and the United States) Porcupine caribou herd, which uses the narrow coastal plain for calving in June and July, has remained near 160,000 animals. The resident muskox population, reintroduced after being hunted to extinction in the late 1800's, now numbers nearly 720. Almost 100 brown bears (*Ursus arctos*) and 43 wolves live on the north slope of the refuge in relatively stable populations.

Arctic fisheries, of little significance in terms of commercial harvest and economic value, constitute a significantly large, locally important contribution to rural economies and provide valuable food for Alaskan Natives. Thorsteinson and Wilson document the status of Arctic cisco (*Coregonus autumnalis*), broad whitefish (*C. nasus*), least cisco (*C. sardinella*), and Dolly Varden char (*Salvelinus malma*) in the nearshore Beaufort Sea north of Prudhoe Bay.

Pacific salmon have always played a major role in the history and economy of Alaska and its commercial, sport, and subsistence fisheries. Burger and Wertheimer (this section) analyze historical and recent salmon harvest information to explore status and trends of Pacific salmon in Alaska. Total salmon harvest in Alaska was estimated at 56,000 salmon in 1878, but rose to over 21 million in 1900. After substantial population declines in the 1920's, 1960's, and 1970's, harvests in most Alaskan populations rebounded, and populations are healthy. Only populations of pink salmon (*Oncorhynchus gorbuscha*) in Prince William

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Sound and chum salmon (*O. keta*) in the Kuskokwim River in western Alaska are experiencing major declines and need attention.

There is a long history of biological studies in Denali National Park and Preserve. Wolves, caribou, brown bears, moose (*Alces alces*), and Dall sheep (*Ovis dalli*) all live in this large ecosystem. The park provides scientists the opportunity to study the natural interactions of these species and serves as a baseline for comparison with areas where hunting occurs. Adams and Mech (this section) document the natural fluctuations expected in species inhabiting such a dynamic and variable environment.

Brown bears on the Kodiak Archipelago are renowned for their large size and dense aggregations along salmon-spawning streams. Barnes et al. (this section) estimate a population of more than 2,800 bears on the archipelago. Through intensive management by Alaska and the U.S. Fish and Wildlife Service, the status of the Kodiak bear population is better now than in the early 1900's.

Populations of the three marine mammals for which the Department of the Interior has management authority—polar bears (*Ursus maritimus*), Pacific walrus (*Odobenus rosmarus divergens*), and sea otters (*Enhydra lutris*)—are healthy. The estimated population of polar bears along Alaska's north coast and the Beaufort Sea is nearly 2,000 and probably larger compared to the early 1900's (Amstrup et al., this section).

About 250 years ago, more than several hundred thousand sea otters were continuously distributed from Baja California, north and west along the Pacific Rim to Kamchatka, and south along the Kuril Islands to northern Japan. When the Russian fur harvest was halted in 1911, only a few surviving colonies, likely numbering a few hundred animals or less, remained. Now, Bodkin et al. (this section) estimate more than 100,000 sea otters living throughout about 75% of their original range, illustrating the healthy recovery of a species after protection and active management.

Pacific walruses in the Bering and Chukchi seas of Alaska and Russia are an important source of meat and ivory for Native peoples of Alaska and the Chukotka Peninsula of Russia (Garner, this section). These marine mammals are also a highly visible indicator of the health of the Arctic marine ecosystem. Cooperative U.S.-Russia surveys conducted at 5-year intervals since 1975 provide estimates ranging from 246,000 walruses in 1980 to 200,000 in 1990. Even though the survey estimates have large confidence intervals, some researchers believe these surveys indicate a general decline in numbers between 1975 and 1990.

The Mentasta caribou herd, a small herd that lives in and around Wrangell-St. Elias National Park and Preserve, exhibits typical population trends and management problems found in many mountain herds in central Alaska and the Yukon Territory of Canada. This herd increased from about 2,000 caribou in the early 1970's to 3,200 in the early 1980's (Jenkins, this section). From 1989 to 1993, the herd decreased to 900 caribou, about a 24% decrease per year.

Klein (this section) documents the distribution and abundance of the tundra or Arctic hare (*Lepus timidus*) in western Alaska. The Arctic hare has long been used for food and clothing by indigenous people living in western Alaska. Arctic hares have declined in number throughout much of their range, though biologists are not sure why.

The Arctic Tundra Ecosystem in Northeast Alaska

by
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The tundra of the coastal plain of the Arctic National Wildlife Refuge (ANWR; Fig. 1) represents nearly pristine, intact Arctic ecosystem. It is unique because of the close arrangement of the plants and animals occurring between the Brooks Mountains and the Beaufort Sea (Fig. 2). The Porcupine caribou (*Rangifer tarandus*) herd (PCH), which ranges between Canada and Alaska, uses the narrow Coastal Plain for calving after migrating hundreds of kilometers from its winter habitat. A now healthy muskox (*Ovibos moschatus*) population was reintroduced in 1969 after being hunted to extinction in the late 1800's. Large predators including gray wolves (*Canis lupus*), brown bear (*Ursus arctos*), and golden eagles (*Aquila chrysaetos*) are also important components as well as sensitive measures of ecosystem health.

Extensive cooperative U.S. and Canadian biological research has occurred on the Coastal Plain during the last decade because it overlies a potentially large and economically productive oilfield. The biological information resulting from these cooperative efforts will guide Congress in its decision to develop the oilfield. The information also provides an excellent measure of the status and trends of key animals in a near-pristine Arctic ecosystem (McCabe et al. 1992).

Monitoring the Ecosystem

We monitored the status and trends of caribou, muskox, and large predators to enhance our understanding of the important relationships of the Arctic ecosystem and to identify and predict the potential impacts of oil and gas development on that system.

Caribou

We periodically photographed and censused the PCH in July from 1972 to 1992. To determine when the caribou were optimally aggregated for photographing, we monitored the formation and distribution of large postcalving aggregations by using intensive aerial reconnaissance, radio tracking, and satellite telemetry.

We estimated the sex and age structure of the PCH during the postcalving aggregation period from aerial and ground counts in 1988, 1989, 1990, and 1992. We estimated annual survival of cows and calves by using aircraft and satellites to periodically track a sample of animals fitted with radio transmitters.

Muskox

We closely monitored the distribution, composition, and size of the muskox population by using radio transmitters, tags, and intensive aerial and ground surveys. We surveyed muskox at 4-8 week intervals in 1987-93 to determine their locations. An average of eight flights per year were flown. We conducted no flights from late November to late January because of severe winter weather and low light conditions.

We also determined sex and age composition from the ground counts. We conducted total counts of the population annually from 1972 to 1993 during aerial surveys and ground counts.

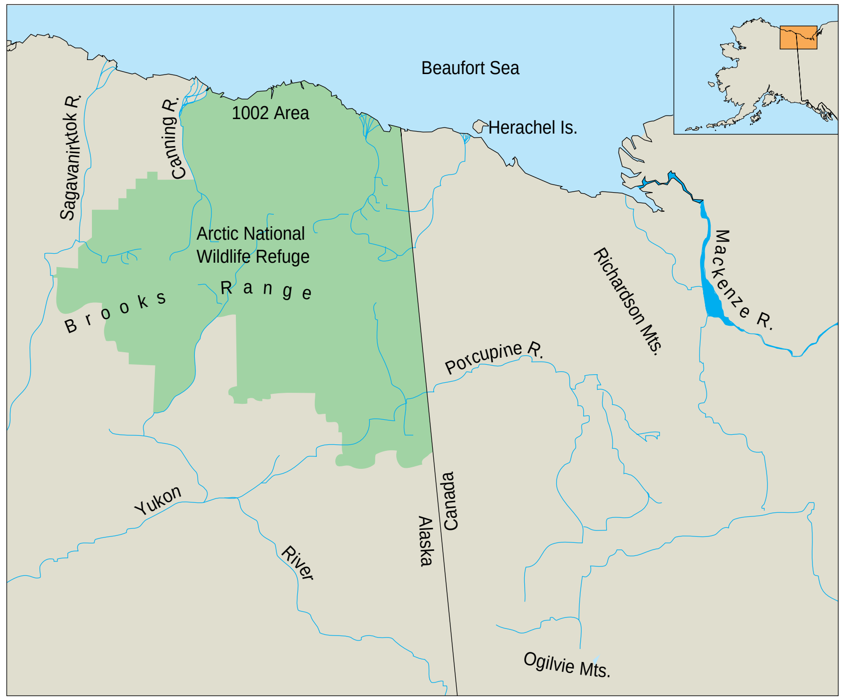
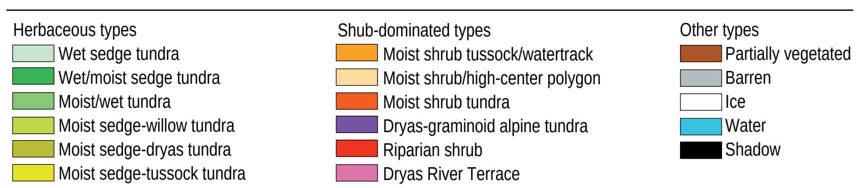


Fig. 1. Arctic National Wildlife Refuge in northeastern Alaska.



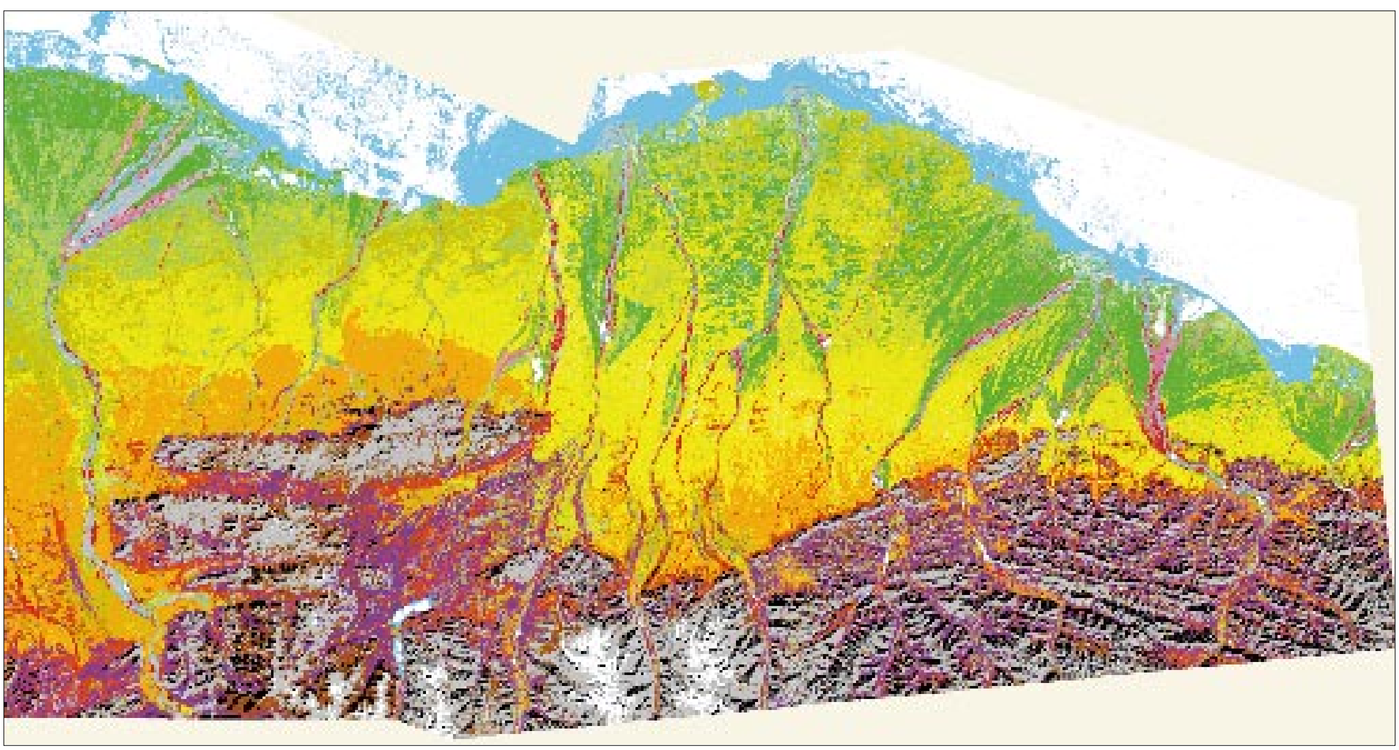


Fig. 2. Land-cover classes on the Arctic National Wildlife Refuge in northeastern Alaska.

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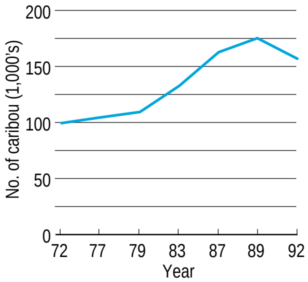

Fig. 3. Photocensus results for the Porcupine caribou (*Rangifer tarandus*) herd, 1972-92.

Predators

We determined the number of brown bears on the Coastal Plain portion of the refuge from densities recorded during extensive aerial surveys in 1983. Subsequent trends in the population were based on composition counts and survival estimates obtained from monitoring radio-tagged bears.

We located wolf dens and packs by monitoring radio-tagged animals and aerial surveys. In 1984, we made a minimum estimate of the population by recognizing individual wolves. We based trends in pack size and composition on ground observations collected at the den site.

We completed aerial surveys of golden eagle nest sites twice each year from 1988 to 1990 to monitor trends in nest occupancy and nestling production.

Status of the Arctic Ecosystem

Caribou

The PCH increased from an estimated 100,000 animals in 1972 to peak at 178,000 in 1989, then dropped to 160,000 in 1992 (Fig. 3). The growth rate averaged 4.8%/year from 1979 to 1989. Since 1989 the population has either stabilized or declined. Ratios of calves to 100 cows ranged from a low of 38 in 1971 to a high of 73 in 1983. This trend in herd productivity generally agrees with the trends in population growth.

We observed no consistent trends in the estimates of annual survival of adult females. The population dynamics of the PCH are similar to the longer term cycles observed in other barren-ground caribou herds.

Muskox

The muskox population on the Coastal Plain increased an average of 20%/year (Fig. 4). After 1986 numbers of muskox in ANWR decreased and then stabilized at about 350 animals, and numbers of muskox east and west of the refuge increased. In 1993 we observed 720 muskox, including 370 on the ANWR Coastal Plain.

Annual productivity for the muskox population on ANWR has averaged about 48 calves per 100 cows since 1985. In the highly productive years of 1984, 1985, and 1988, calf-to-cow ratios were greater than 70:100 and calves accounted for more than 21% of the total population. Age at death for five known-age cows averaged 13.8 years (range: 9-19) and annual survival averaged 88% for adult cows and 77%-78% for yearlings and calves. Changes in distribution occurred during years following winters in which biologists observed lower productivity and survival of young animals and adult cows. The dynamics and behavior of the population are typical of animals reintroduced into suitable habitat.

Predators

In 1983 we estimated that there were 108 brown bears on the north slope of ANWR. Between 1983 and 1993 estimates of survival and reproductive rates of the bear population were stable and distribution and movements of bears were consistent. This consistency suggests that the bear population is stable.

In 1984 we estimated that a minimum of 34 wolves occurred on the north slope of ANWR. A mean litter size of 4.2 during 1988-90 was consistent with the 3.0 reported for ANWR in 1984 and 4.3 in 1985. Population size appears stable.

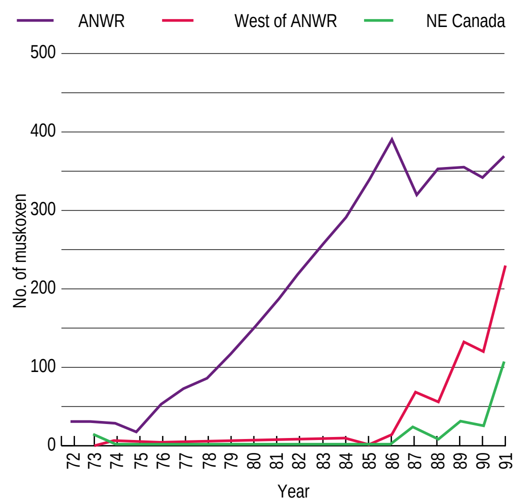

Fig. 4. Growth and stabilization of the pioneering muskox (*Ovibos moschatus*) population within the Arctic National Wildlife Refuge and adjoining areas.

Between 1988 and 1990 we observed 31 nesting attempts by golden eagles on the north slope of the ANWR between the Canning and Kongakut rivers. Twenty-seven of the 31 (87%) breeding pairs produced 33 young, resulting in 1.22 young per successful pair. The number of young remained constant from 1988 to 1990, suggesting that the ANWR eagle population is also stable.

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Anadromous Fish of the Central Alaska Beaufort Sea

by
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Today, more than 25 years after the discovery of oil in Prudhoe Bay, it is hydrocarbon resources, and not fish or wildlife, that most Americans equate with Alaska's North Slope. From national and statewide perspectives, Arctic fisheries are of little significance in terms of total landings and economic worth. But small, northern fisheries contribute to rural economies and provide necessary sources of protein for Alaska's Native people. As such, the welfare of exploited fish populations and protection of regional lifestyles are dominant environmental and sociological themes associated with the industrialization of Arctic coastlines. Fully one-third of adult Inupiat Eskimos participate in subsistence fisheries. They capture about 96,000 kg (210,000 lb) of fish annually, an amount that rivals the yearly Native harvest of bowhead whales. Commercial fishermen harvest another 40,000 fish in a fall-winter fishery.

The continued development of the Prudhoe Bay oilfields in Alaska required the construction of two solid-fill gravel causeways (West Dock in 1974-75, extended in 1976 and 1981; Endicott Causeway in 1984-85) extending several kilometers offshore (Fig. 1). These causeways can cause transient changes in local fish habitat. Biologists are concerned that fish populations may be negatively affected when causeway-induced changes in habitat quality, quantity, or availability combine with regional fishery removals. Because nearshore water circulation is wind-driven, these changes vary with wind speed, direction, and duration.

Arctic cisco (*Coregonus autumnalis*), broad whitefish (*C. nasus*), least cisco (*C. sardinella*), and Dolly Varden char (*Salvelinus malma*) are the fish of primary concern. These anadromous species have life cycles that include annual migrations from winter habitats in fresh water to summer feeding habitats in salt water.

Summer habitats are in coastal environments, which are vulnerable to industrial developments. The species have adapted to Arctic conditions through strategies that promote their welfare, including complex migrations, variable freshwater rearing periods, being long-lived with late maturity, and having low recruitment rates.

Fish Monitoring

Inventories of fish habitats, populations, and fisheries in the Alaska Beaufort Sea began in earnest during the mid-1970's. The construction of the West Dock and Endicott causeways required environmental monitoring and other research to evaluate the effects of these structures. The study area included Prudhoe Bay and 120 km (75 mi) of adjacent coastline between the Colville and Sagavanirktok river deltas (Fig. 1).

Biologists initiated fish-monitoring studies around causeways in 1981. For monitoring they incorporated common fishery techniques used to estimate population health and size (Norton 1989; Benner and Middleton 1991). Their sampling included live captures of fish along the coast, standard biological measurements, and physical assessments of fish habitat. They conducted their fieldwork between June and mid-September. Biologists have also compiled annual fishery statistics from the Colville River since 1967.

We examined three data sets: season-averaged catch rates; season-long estimates of population size from mark-recapture studies; and effort-adjusted catch rates and total harvests from the commercial fishery. Because sampling effort varied each year, we derived coastal indices of abundance from five permanent stations established in 1985. We based our counts of small Arctic ciscoes and broad whitefish on all available catch records.

We defined groups of fish of the same species that comprise the same age or size ranges (called cohorts). For Arctic cisco and broad whitefish: cohort I—age 0 (young-of-the-year), cohort II—age 1, cohort III—ages 2 and 3, and cohort IV—age 4 or older. For least cisco: cohort I less than 180 mm (7.1 in) long and cohort II at least 180 mm (7.1 in) long. For Dolly Varden char: cohort I—less than 350 mm (13.8 in) long, and cohort II—at least 350 mm (13.8 in) long.

Arctic Fish Species

Arctic Cisco

Biologists believe that Arctic cisco inhabiting the central Alaskan Beaufort Sea originate in the

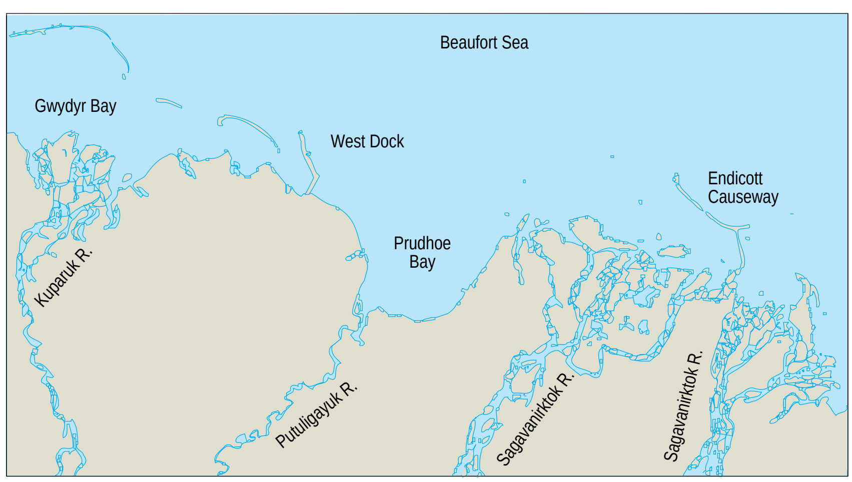
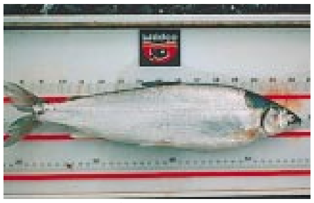
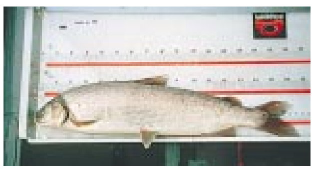


Fig. 1. Prudhoe Bay study area showing West Dock and the Endicott Causeway, Alaska.

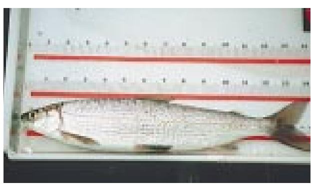


Arctic cisco (*Coregonus autumnalis*). Courtesy R. West, USFWS

Small Arctic cisco.
Courtesy W.J. Wilson, LGL Research Alaska, Inc.



Broad whitefish (*Coregonus nasus*). Courtesy R. West, USFWS



Least cisco (*Coregonus sardinella*). Courtesy R. West, USFWS

Dolly Varden char (*Salvelinus malma*).
Courtesy W.J. Wilson, LGL Research Alaska, Inc.

Mackenzie River, Canada. Upon emergence, young fish are swept downstream and transported along the coast with prevailing nearshore currents. During years when easterly winds prevail, currents carry juveniles westward into Alaskan waters. Their migration is passive and recruitment varies annually. Juveniles in Alaska become mature after 7-9 years. They then return to spawn in the Mackenzie system. In Alaska, fish winter in the Colville River, and to a lesser extent, in the Sagavanirktok River deltas. Each June, young fish move to the coastal sea and are common in Prudhoe Bay. The commercial gill-net fishery is selective for 5- and 6-year-old fish.

Trends in abundance for four age groups of Arctic cisco captured in Prudhoe Bay since 1985 illustrate the cyclic nature of the species abundance by cohort in northern Alaska (Fig. 2a). The size and age structure observed in the population before 1985, and after causeway construction, generally follow predicted patterns expected from historical wind records.

The annual commercial catch of Arctic cisco from the Colville River fishery has ranged from 9,000 fish in 1979 to 72,000 in 1973 (Fig. 3). During the same period mean catch-per-unit effort (CPUE) ranged from 12 fish/net/day in 1979 to 195 fish/net/day in 1986. Biologists think that the availability of harvestable fish is due to natural mortality and interannual variations in numbers of migrants from Canada.

Broad Whitefish

Broad whitefish are indigenous to the Sagavanirktok and Colville rivers. Monitoring concentrated on the Sagavanirktok's population because of causeway construction in the river delta. Cohort analysis shows low catch rates in Prudhoe Bay from 1985 to 1987, followed by annual increases that peaked in 1990, and declining abundance thereafter (Fig. 2b). The existing data suggest a cycle of strong year-class success followed by several years of poor juvenile survival, which probably results from adult displacement of juveniles from optimal winter habitats.

A 10-year population cycle is suggested, underscoring the critical, if not limiting, nature of freshwater habitat for broad whitefish. Without long-term monitoring, the reduced abundance of juveniles in the late 1980's would have been attributed to causeways and not competition between fish at freshwater wintering sites.

Least Cisco

The center of distribution for least cisco in the Alaskan Beaufort Sea is the Colville River. Biologists have captured all cohorts of least cisco in Prudhoe Bay. No trends in CPUEs are apparent from cohort analysis (Fig. 2c), although catch rates were high in 1990, possibly because of prevailing west wind conditions that year.

Least cisco are of secondary importance in the

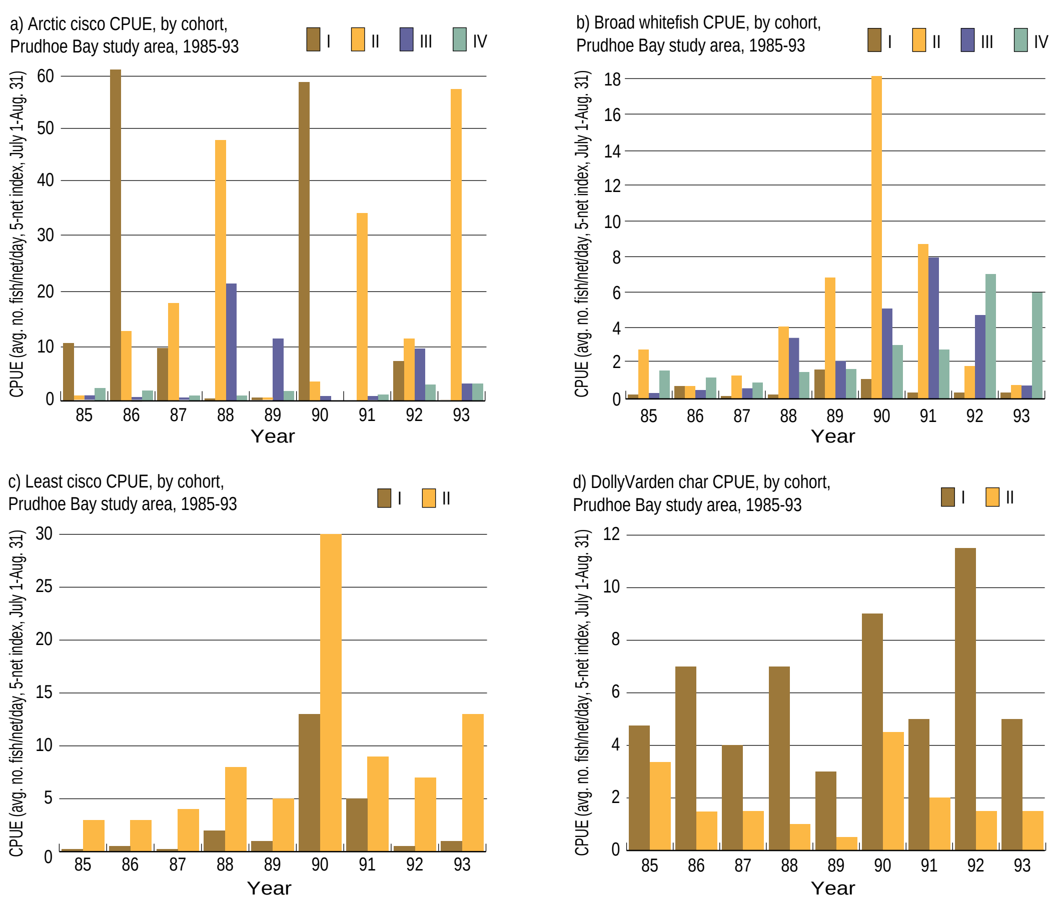


Fig. 2. Season-averaged catch rates (catch-per-unit-effort, CPUE) for (a) Arctic cisco (*Coregonus autumnalis*) cohorts I-IV, (b) broad whitefish (*C. nasus*) cohorts I-IV, (c) least cisco (*C. sardinella*) cohorts I and II, and (d) Dolly Varden char (*Salvelinus malma*) cohorts I and II, in the Prudhoe Bay study area, 1985-93 (Endicott Fish Monitoring Program, BP Exploration [Alaska], Inc.).

Colville River fishery. Annual catches have ranged from 6,000 fish in 1993 to 38,000 in 1983 (Fig. 3). Biologists believe that the annual variability observed in the catches reflects population fluctuations associated with natural mortality and fishing effects. The apparent decline in numbers of least cisco since 1991 cannot be explained by the existing data, and consequently residents of the North Slope Borough are closely monitoring this fishery.

Dolly Varden Char

Major populations of Dolly Varden char occur in the mountain streams and rivers of the eastern Brooks Range. The char is growing in importance as a recreational species; an estimated 1,000-3,500 fish are harvested annually (Alaska Department of Fish and Game 1993).

There are no apparent trends in population abundance (Fig. 2d). The Dolly Varden char is a highly mobile and tolerant species that uses freshwater, estuarine, and marine habitats. Catches tend to be highest during early and late summer when the fish are migrating near river mouths. Recent findings show that char from the eastern Alaska Beaufort Sea and Canada are present in Prudhoe Bay during summer.

Conclusions

These fish differ in their susceptibility to causeway changes in Prudhoe Bay. The broad whitefish is highly susceptible because of its more limited distribution and habitat preferences in the Sagavanirktok River delta. Young-of-the-year Arctic cisco must cross the Prudhoe Bay area to reach prime overwintering habitat; they forage in these coastal waters for several years thereafter. Continued exposure to habitat changes that affect summer habitat quality, access, or migration poses moderate risks to this species. Much of the study area is at the eastern limits of the Colville River population of least cisco and thus, at present, this species is considered at low risk from the existing causeways. Similarly, Dolly Varden char are probably at low risk because of their ability to use more offshore marine waters for feeding and migration.

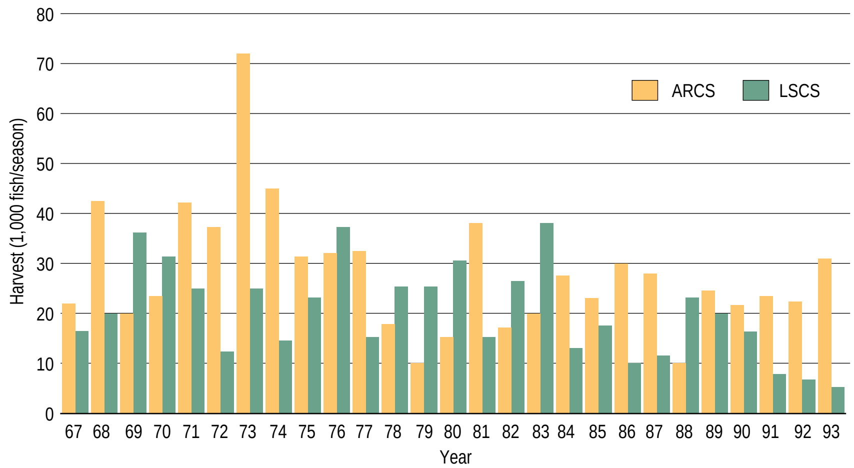


Fig. 3. Total annual commercial harvest of Arctic cisco (ARCS) and least cisco (LSCS) for the Colville River, 1967-93 (Endicott Fish Monitoring Program, BP Exploration [Alaska], Inc.).

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Pacific Salmon in Alaska

by
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Pacific salmon (Salmonidae) have played a major role in the history and economy of Alaska and its commercial, sport, and subsistence fisheries; Alaska currently produces about 80% of all salmon harvested in the western United States and Canada. Before commercial exploitation in the late 1800's, salmon were a main food source for Alaska's Native peoples, who subsisted by using an estimated 12 million salmon annually (Pennoyer 1988). By the end of the century, the total commercial harvest in Alaska had expanded to an estimated 56,000 salmon in 1878 but rose to more than 21 million by 1900 (Rigby et al. 1991). Since 1980 the annual commercial harvest has exceeded 100 million salmon in all but one year and is presently at a record high of more than 190 million (Fig. 1). The annual sport harvest of salmon in Alaska has averaged about 1 million fish over the past several years (Mills 1993), as has the subsistence harvest (INPFC 1992). Science-based management, "limited-entry" fishing, effective law enforcement, and establishment of fixed escapement goals for specific rivers are among the factors responsible for increased salmon abundance.

Apart from their economic, recreational, and subsistence importance, salmon are a vital link in various Alaskan ecosystems. Large populations of bears (Ursidae) and eagles (Accipitridae) in some parts of Alaska, for example, depend on late-spawning salmon as a food source before winter. Also, the carcasses of spawned-out salmon are a key element in otherwise nutrient-poor lakes and rivers. Because Alaska has a comparatively greater amount of unaltered habitat and a larger number of wild salmon stocks than do other parts of the Northwest, monitoring population status and trends is particularly important to alert managers to problems before irreversible losses occur.

We summarize trends in harvest and escapement (fish that survive sport, commercial, and

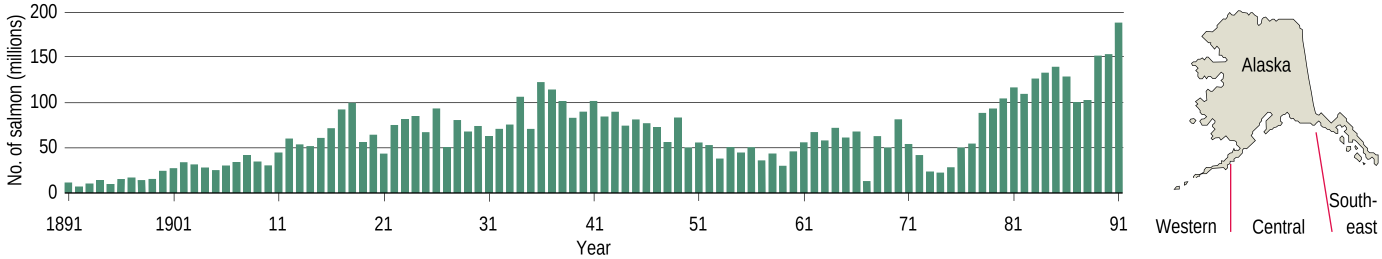

Fig. 1. Statewide commercial salmon harvest for all species of Alaskan salmon (excluding hatchery-produced fish), 1891-1991 (Rigby et al. 1991).

subsistence fishing) for five species of salmon in Alaska: pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), sockeye (*O. nerka*), chinook (*O. tshawytscha*), and coho salmon (*O. kisutch*). We present historical records and data for three major regions of the state: southeastern, central, and western (Fig. 1). This summary is based on data from similar efforts completed or in progress by the Alaska Chapter of the American Fisheries Society, the Alaska Department of Fish and Game, the National Marine Fisheries Service, and the U.S. Forest Service.

The data we present originate from the Alaska Department of Fish and Game (various Area Management Reports). Information on the annual status of Alaskan salmon populations comes from numerous state and federal publications and is presented in three ways. First, we tabulate the trends in salmon escapement by species. This tabulation was done for species in central and western Alaska from 1968 to 1984 (Konkel and McIntyre 1987), for pink and chum salmon in southeast Alaska from 1960 to 1993 (Wertheimer in press), and for southeast sockeye, chinook, and coho stocks from 1960 to 1992 (C. Halupka, U.S. Forest Service, personal communication). These trend summaries do not include all populations, but are limited to those for which escapement data are readily available in a usable format.

Second, we graph the historical harvest for each species from 1891 to 1991 (Rigby et al. 1991). Because of Alaska's limited-entry fishing policy (since 1975) and the use of fixed-escapement goals, these summaries of commercial harvest may be a useful indicator of population trends.

In our third approach, we graph the escapements of pink, sockeye, chinook, and chum salmon (data for coho salmon were inadequate) in key areas of Alaska based on Department of Fish and Game Annual Management reports (1960 to 1992). This method provides an index of salmon abundance and is particularly relevant in determining sockeye salmon trends because management of this species is often based on in-season escapement enumeration. It also allows us to compare a species escapement trend in a specific area (for example, Prince William Sound) with its overall trend in other areas of Alaska. Because many Alaskan stocks are managed to meet a target escapement goal, however, a decreasing trend may not indicate a decrease in overall productivity.

Population Trends for Five Species

Pink Salmon

The trend summary for pink salmon was limited to the southeast and central regions of Alaska, where much of the harvest occurs. Most populations showed either no significant trend or were increasing in size (Table).

The plot of statewide harvest of pink salmon over time (Fig. 2a) was similar to the 100-year statewide harvest totals for all species (Fig. 1). Hatchery production of pink salmon is considerable in the central portion of Alaska and may account for up to 51% of the catch (Wertheimer in press). Statewide, a record catch occurred in 1991, when 93 million wild pink salmon and 35 million hatchery pink salmon were harvested (Fig. 2a; Wertheimer in press).

Table. Summary of trends in escapement for populations of Pacific salmon in Alaska by species and region over time. Escapement trends were classified as increasing or decreasing if the slope of the regression of escapement over time was significantly different ($P<0.05$) from zero. (NA— not available.)

Species	Years	Number of populations showing: No trend	Decrease	Increase	Source of data*
Pink salmon					
Southeast	1960-93	312	9	150	1
Central	1968-84	102	0	32	2
Western	NA	NA	NA	NA	—
Chum salmon					
Southeast	1960-93	28	5	5	1
Central	1968-84	61	11	3	2
Western	1968-84	10	2	0	2
Sockeye salmon					
Southeast	1960-92	93	10	4	3
Central	1968-84	58	0	35	2
Western	1968-84	16	0	12	2
Chinook salmon					
Southeast	1960-92	35	0	6	3
Central	1968-84	20	0	23	2
Western	1968-84	24	1	15	2
Coho salmon					
Southeast	1960-92	107	12	9	3
Central	1968-84	4	0	4	2
Western	NA	NA	NA	NA	—

*Source of data:
1—Wertheimer in press.
2—Konkel and McIntyre (1987).
3—C. Halupka, U.S. Forest Service, personal communication.

Pink salmon management in Prince William Sound is extremely complex. Record harvests of pink salmon (30-50 million fish) in Prince William Sound during 1990 and 1991 declined to 9 million in 1992. The decline in catch and recent declines in escapement (Fig. 3a) may be a result of density-dependent mortality from increased hatchery releases, environmental alterations, or changing oceanic currents. It should be noted, however, that the pink salmon escapements in Prince William Sound, Cook Inlet, and Kodiak increased in 1993 (Fig. 3a). The 1989 peak in the combined escapements for pink salmon in Cook Inlet and Kodiak reflects fishery closures related to the *Exxon Valdez* oil spill.

Chum Salmon

The trend summary for chum salmon was available for all regions of Alaska. Decreasing trends were more common than increases (Table). The statewide harvest of chum salmon attained record levels through the mid-1980's (Fig. 2b) and has generally increased in all areas of Alaska since the mid-1970's. Although the catch in western Alaska is almost all from wild populations, hatchery contributions are now

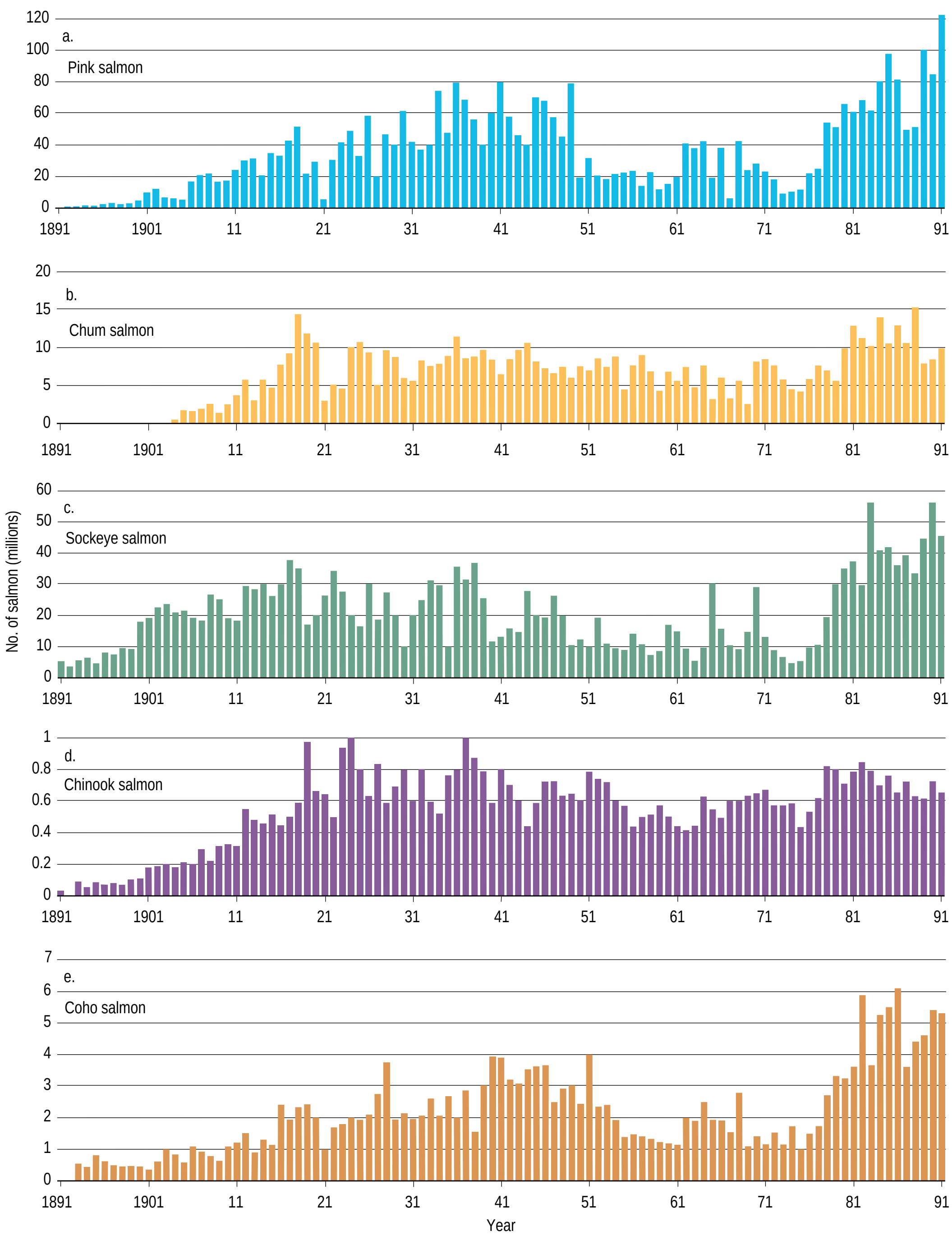

Fig. 2 a-e. Statewide commercial harvest of Alaskan salmon by species, 1891-1991 (Rigby et al. 1991).

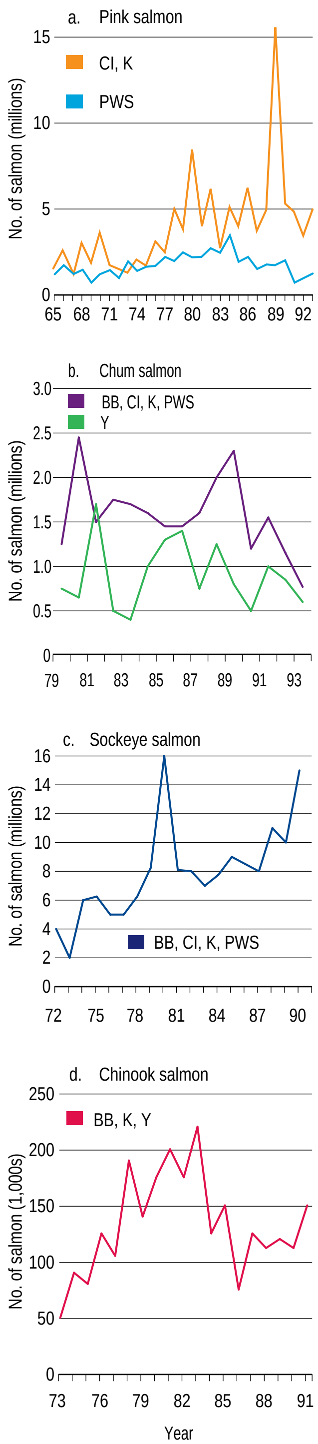

Fig. 3 a-d. Salmon escapements over time in select areas of Alaska. (BB—Bristol Bay; CI—Cook Inlet; K—Kodiak; PWS—Prince William Sound; Y—Yukon.)

about 12% of the catch in the central region and about 33% in southeastern Alaska (Wertheimer in press).

Chum salmon escapements (1979-93) in central and western Alaska (Fig. 3b) have generally declined, as have the escapements of fall-run chum salmon in the Yukon River. These declines have directly affected western Alaska commercial and subsistence users who depend on the chum salmon resource. Several factors could be responsible for this decline, including oceanographic change, density-dependent competition at sea with large numbers of chums released by hatcheries in Russia and Japan (Ishida et al. 1993), and interception by high seas drift-net fisheries (Olsen 1994). In addition, fishing effort has increased in recent years from expanding in-river commercial and subsistence chum salmon fisheries.

Sockeye Salmon

A trend summary was possible for sockeye salmon in all regions of Alaska. Most populations were either stable or increasing (Table). Statewide sockeye salmon harvest is at a record level (Fig. 2c), and the catch throughout Alaska has risen substantially since the early 1970's (Wertheimer in press). Escapement also appears to be increasing for most populations (Fig. 3c). In addition to the few stocks in southeast Alaska that have declined, a decline in Cook Inlet sockeye salmon is predicted over the next 2 years. After many spawning adults escaped harvest when fisheries were closed in 1989 because of the *Exxon Valdez* oil spill, too many fry were produced to be supported by their habitat (D. Schmidt, Alaska Department of Fish and Game, personal communication). The resulting increase in fry mortality will probably be a factor in the abundance of Cook Inlet sockeye salmon in the immediate future.

Chinook Salmon

The trend summary for chinook salmon suggests that most populations are either stable or increasing (Table). Although present commercial harvest of chinook salmon statewide is slightly lower than the average historical level (Fig. 2d), the catch appears to be more stable than for all species combined (Fig. 1). A recent decrease in the quota for southeastern Alaska troll fisheries may be a factor in the stable catch of chinook salmon. Sport harvest of chinook salmon has increased substantially over the past several years (Mills 1993) and now exceeds 10% of the commercial catch (Wertheimer in press). Catches of chinook salmon declined in nearly all regions of Alaska in the early 1970's, rebounded through the early 1980's, and have begun to decrease since that time. High seas drift-net and trawl fisheries that target other

Sockeye salmon return to spawn in numerous Alaskan streams each summer.

species may be factors in the minor decline in chinook salmon harvest in western Alaska (Olsen 1994; Table). When actual escapements are plotted for several areas of Alaska, however, the trends are generally increasing (Fig. 3d).

Coho Salmon

A trend summary was possible for coho salmon stocks only in the southeastern and central regions of Alaska (Table). Overall, fewer data have been collected for coho than for other species of salmon because of their late run timing, smaller population sizes, and use of remote, heavily vegetated watersheds. Most populations analyzed in southeastern Alaska showed no trend: some increased and some decreased (Table). Of the eight populations examined from central Alaska, half increased and none decreased.

Statewide harvest of coho salmon is at a record level (Fig. 2e), as is the catch in all regions of Alaska (Wertheimer in press). Data were insufficient to plot coho salmon escapements in key areas of Alaska. Based on catch data alone, abundance of coho salmon is generally increasing (Wertheimer in press). For some of the populations that are declining in southeastern Alaska (Table), habitat effects associated with logging may be a factor; however, an equal number of declining populations in southeast Alaska are in pristine areas (C. Halupka, U.S. Forest Service, personal communication).

Conclusions

The population trends and escapements of pink, sockeye, chinook, and coho salmon in Alaska are generally stable or increasing based on the data analyzed. A recent decline in chum salmon escapements has occurred in central and western Alaska, the cause of which may be related to density-dependent factors and oceanic change in the marine environment. In many Alaskan streams, salmon abundance has not been determined or analysis of data is incomplete.

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Wolves and Caribou in Denali National Park, Alaska

by
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Management of gray wolves (*Canis lupus*) and their prey in interior Alaska has been controversial for three decades (Harbo and Dean 1983). Recently, debate was rekindled with renewed interest in wolf control to bolster two populations of caribou (*Rangifer tarandus*). Our research in Denali National Park provides insights into the declines in caribou numbers over the last few years that are the basis of recent wolf control proposals. Our observations of fluctuating populations also illustrate the complexity of managing these predator-prey systems to meet a diverse array of public interests.

Wolves and caribou are two components of the large mammal community of Denali National Park that also includes grizzly bears (*Ursus arctos*), moose (*Alces alces*), and Dall sheep (*Ovis dalli*). With the 1980 park expansion to more than 18,800 km^2 (7,300 mi^2) of central Alaska, this large mammal system became the only one of its kind that is virtually unaffected by human harvest. Therefore, Denali provides a unique opportunity to understand the natural interactions of these species and serves as a baseline for comparison with areas where hunting or other active wildlife management occurs.

We have studied Denali's wolves and caribou since 1986 to determine their numbers and status and understand their natural interactions in this protected subarctic ecosystem. Our studies began near the end of more than a decade of mostly light winter snowfalls of around 100 cm (39 in)/yr. Since winter 1988-89, we have experienced five consecutive winters with above-average snowfalls, including two record-setting years. During winters 1990-91 and 1992-93, more than 390 cm (154 in) of snow fell, four times as much as in the early years of our study. This change in snowfall had profound effects on the wildlife in central Alaska. The population trends of Denali's caribou and wolves are strong evidence of the natural fluctuations to be expected in species inhabiting such dynamic and variable environments.

Counting Caribou and Wolves

Our research has relied heavily on radiotelemetry to study the dynamics of the wild caribou and wolf in Denali. We can easily find our radio-collared study animals by using signal-receivers mounted in small airplanes (Mech 1975). Locating radio-collared wolves allows us to count their packmates, determine the number of pups born to each pack, gain information on survival and dispersal, determine the size and location of each pack's territory, and estimate the total number of wolves in our study area (Mech 1973). Regular monitoring of radio-collared caribou provides information on calf production, survival, and seasonal distribution of the herd, and makes it easier to complete aerial surveys to estimate herd size and composition (Adams et al. in press).

Population and Weather

The Denali caribou herd grew from about 1,000 in 1975 to 2,500 by 1986, during a decade of mostly below-average snowfalls, and was increasing at about 7% per year in 1986 when

Courtesy L.G. Adams, NBS

Wolf carrying week-old caribou calf.

our research began (Adams et al. in press; Figure). About 46 wolves inhabited the 10,000-km^2 (3,860-mi^2) range of the caribou herd in the early years of our study (Meier et al. in press). The number of wolves was lower than we expected based on the abundance of large prey species in Denali. Light snowfalls were favorable to caribou, and few died. Wolves preyed primarily on moose; the few caribou they took were usually very young or very old (Mech et al. in press). Times were tough for wolves, with poor production of pups and high dispersal rates for young wolves. Also, fights between packs resulted in the deaths of several wolves.

With the onset of more severe winters, beginning with winter 1988-89, wolf numbers rapidly increased to 81 wolves in just 2 years (Meier et al. in press; Figure), primarily because of higher pup production and less dispersal of young wolves. Caribou were more vulnerable to predation in the deep snow and replaced moose as the most important prey species for wolves. Losses of adult cows increased eight-fold to nearly 20% per year. Fewer than 9% of the calves survived to 4 months old, compared to nearly 60% following the light snow winters (Adams et al. in press). The caribou herd stopped growing in 1990 at about 3,300 and plummeted to 1,700 by 1993, a 50% decline in only 3 years (Figure). With declining prey, the wolves also declined to about 60 wolves within the caribou herd's range, a 23% reduction between March 1990 and March 1993.

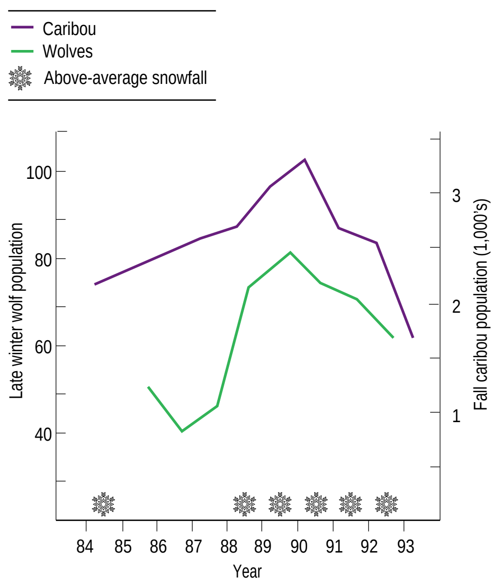

Figure. Wolf and caribou population trends in Denali National Park, Alaska, 1984-93.

The fluctuations in wolf and caribou numbers observed in Denali National Park are probably indicative of normal adjustments to the highly variable winter weather of the region. Within 8 years, the caribou herd increased by 36% and declined by 50%. At the same time, the wolves almost doubled in number and then declined halfway back to their original numbers.

The trends noted for the Denali caribou herd are representative of population trends of several mountain caribou herds throughout central Alaska, including the Chisana and Mentasta herds in the Wrangell Mountains, and the Delta and Macomb herds east of Denali Park in the Alaska Range. Unlike the Denali herd, which has been closed to hunting for nearly 20 years, these other caribou herds are important resources for subsistence and sport hunters alike. Hunting seasons have been closed for all four caribou herds because of the declines in the last few years.

These reductions in hunting opportunities have led to debates over the merits of wolf control to provide more caribou for human harvest. Arguments regarding allocation of harvestable wildlife between subsistence and sport hunters will intensify when hunting seasons are reopened. Although the future of wolves and caribou in interior Alaska is secure, natural fluctuations like those described here can be expected to generate continued controversy over the management and allocation of these important wildlife resources.

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Kodiak Brown Bears

by
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Brown bears (*Ursus arctos middendorffi*) on the Kodiak Archipelago are famous for their large size and seasonal concentrations at salmon streams. Sport hunting of Kodiak bears has been popular since World War II. Their value as captivating subjects to observe or photograph is a more recent development that is increasing rapidly; visitors from around the world come to experience brown bears on Kodiak, adding substantially to Alaska's economy.

An equally important contribution of brown bears is their value as an indicator of ecosystem vitality. Despite high population numbers, Kodiak bears are vulnerable to the environmental effects that have seriously depleted brown bear populations in Europe and parts of North America (Cowan 1972; Servheen 1990). They are long-lived mammals that require large expanses of land to meet biological needs, and their low reproductive rate limits population recovery. Energy development, depletion of salmon resources, and recreational growth are factors that can adversely affect bears and, in doing so, signal a loss of environmental quality affecting many species.

Management of Kodiak brown bears is directed at maintaining current density, distribution, and habitat-use patterns. This goal is challenged by growing levels of commercial and private use throughout the region. An immediate concern is cabin and lodge development on 121,500 ha (300,000 acres), formerly part of the Kodiak National Wildlife Refuge, that were deeded to Alaska Natives via the Alaska Native Claims Settlement Act. Much of that Native-conveyed land is coastal or riparian habitat especially important to brown bears during summer and fall. Concurrently, recreational use of the Kodiak refuge is increasing about 10% annually (USFWS 1987). Sport fishing, bear photography, and deer and elk hunting often put bears and humans in direct conflict (Smith et al. 1989).

Timber harvest on Afognak Island, uncertain trends of salmon populations due to natural or human-caused events (e.g., *Exxon Valdez* oil spill), and hydroelectric development (Smith and Van Daele 1990) could impose additional long-term effects on localized bear populations.

Population Monitoring

Sport harvest records, available since 1950 (Troyer 1961), provide the most comprehensive information on Kodiak brown bears. In addition, biologists use aerial surveys to monitor population and habitat-use trends of brown bears on southwest Kodiak Island, an area that supports the highest bear densities and approximately 15% of Kodiak Island's bear population (Barnes et al. 1988).

We assessed status of the Kodiak bear population from estimates of density for representative study areas on northern, southwestern, and eastern Kodiak Island. We radio-collared a sample of bears on each area and estimated bear density using ratios of marked and unmarked bears observed from small aircraft (Miller et al. 1987). Brown bear abundance on other geographic units of the Kodiak Archipelago was estimated by comparing those units with the study areas.

Status and Trends

Sport Harvest Records

Excessive and localized harvest of brown bears in the mid-1960's (Fig. 1) prompted biologists to impose restrictions (season length, area closures) that dramatically reduced harvest. A sharp rise in hunting in the early 1970's produced another increase in harvest. In 1976 the Alaska Department of Fish and Game began an area permit system that distributed hunting more equitably throughout the archipelago. Since 1980 the harvest pattern has been relatively stable, with an average annual take of 163 animals (Fig. 1).

Sex composition of the sport harvest has remained relatively stable despite fluctuations in yearly harvest. From 1987 to 1993 the female portion of the harvest has ranged from 32% to 38%.

Age and skull measurements of harvested bears provide further evidence of population stability. Mean ages of males and females taken during 1981-93 (7.3 and 7.4 years, respectively) were slightly higher than during 1969-80 (6.3 and 6.8 years, respectively), but we attribute this difference to sampling variation (Fig. 2). Skull

Courtesy D. Menke, USFWS

Adult brown bear on Dog Salmon Creek, Kodiak National Wildlife Refuge, Kodiak Island, AK.

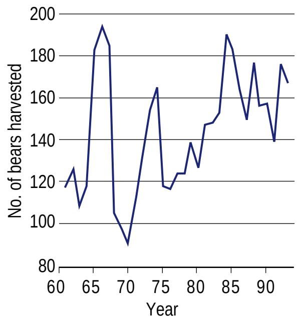

Fig. 1. Annual sport harvest of Kodiak brown bears, 1961-93.

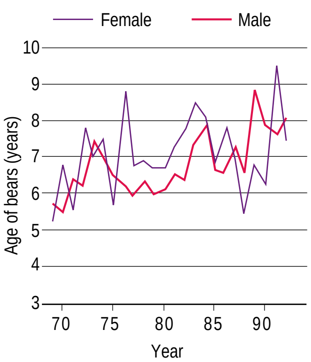

Fig. 2. Mean age of Kodiak brown bears harvested by sport hunters, 1969-92.

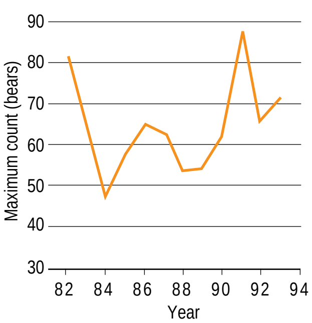

Fig. 3. Maximum counts from aerial surveys of brown bears concentrated along salmon-spawning streams on southwest Kodiak Island, 1982-93.

measurements (length plus width) of harvested bears, which generally indicate bear size (Glenn 1980), have remained consistent over time.

Collectively, sport hunting records point to a stable bear population on the Kodiak Archipelago. A comparison of average annual harvest and estimated population size indicates that harvest is at or near the maximum sustainable level (Miller 1990), and managers should closely monitor additional effects on the bear population arising from increased mortality or other factors.

Aerial Stream Surveys

Adjusted maximum counts from stream surveys ranged from 47 to 87 bears per survey over the past 12 years, but there has not been any consistent trend in the counts during this period (Fig. 3). The stream survey counts are used as an index to population size, but they are affected by many other factors such as timing of the surveys relative to peak bear concentrations and strength of salmon runs.

We consider estimates of composition based on the stream surveys more reliable. Annual estimates of the proportion of maternal females have varied little from the overall mean of 24% during this period. Taken together, the count and composition data suggest that the brown bear population in this area remains relatively stable.

Population Abundance

Estimates of brown bear density on three study areas on Kodiak Island ranged from 0.29 to 0.35 bears/km^2 (0.75 to 0.91 bears/mi^2). Habitats represented by the areas included precipitous mountain terrain, shrub-covered slopes, riparian zones, coastal habitat, and extensive bog and heathland flats. Extrapolating those density estimates to comparable habitats on other geographical areas provided an estimate of 2,842 bears for the Kodiak Archipelago or about 0.23 bears/km^2 (0.60 bears/mi^2). Bear density was highest at Karluk Lake (0.42 bears/km^2 [1.09 bears/mi^2]) and lowest on small, isolated islands (0.04 bears/km^2 [0.10 bears/mi^2]).

Management Considerations

Available information suggests that the status of the Kodiak brown bear population is better now than in some earlier periods. In the early 1900's bears were commercially hunted for their hides or indiscriminately killed as competitors of fisherman and ranchers (Troyer 1961; Smith et al. 1989). During the 1960's bears were killed in a controversial control program undertaken to reduce conflicts with livestock on northeast Kodiak Island (Eide 1965), and excessive sport harvest occurred on parts of southwest Kodiak Island. These events undoubtedly affected bear distribution and abundance in local areas. However, future management of brown bears and their habitat will face new problems, including accelerated timber harvest, construction of cabins on bear habitat, and additional hydroelectric development. Added to all these threats is the long-term problem of expanding recreational use. Effective management of the bear population in upcoming years will depend on inventory methods that can detect population change in a timely manner.

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Polar Bears in Alaska

by
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The polar bear (*Ursus maritimus*) is the top predator of the Arctic marine ecosystem. Polar bears prey primarily on ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*), which live exclusively on the sea ice (Smith and Stirling 1975; Stirling and Archibald 1977; Smith 1980), but they also can kill larger prey such as walruses (*Odobenus rosmarus*) and white whales (*Delphinapterus leucas*; Kiliaan and Stirling 1978; Fay 1982; Calvert and Stirling 1990; Stirling and Derocher 1990).

Polar bears move several thousand kilometers annually and over years occupy areas that can exceed 500,000 km^2 (nearly 200,000 mi^2; Garner et al. 1990; Amstrup and Durner, unpublished data; Fig. 1). Polar bears are circumpolar in the northern hemisphere, but they live in several largely discrete subgroups, rather than one homogeneous pan-Arctic population (Harington 1968). We used radio telemetry to show that two partially discrete subpopulations live adjacent to Alaska (Fig. 2). One subpopulation occurs largely in the Beaufort Sea of Alaska and neighboring Canada. Animals from this Beaufort Sea stock appear to spend about 25% of their time along the Chukchi Sea coast of northwestern Alaska (Amstrup and Durner, unpublished data). The Chukchi Sea subpopulation winters in the northern Bering Sea and southern Chukchi Sea adjacent to Russia and western Arctic Alaska, and its members seldom enter the Beaufort Sea (Fig. 2).

Low reproductive rates make polar bears vulnerable to excessive hunting. Yankee whalers, local resident Native people, and aerial hunters reduced numbers and local distributions of polar bears in many areas (Leffingwell 1919; Hanna 1920; Lønø 1970; Mowat 1984; Amstrup et al. 1986). Polar bears are also potentially vulnerable to industrial developments and other human activities that have increased in the Arctic recently (Lentfer 1983; Amstrup et al. 1986). Polar bears and the seals on which they prey may also be among the first species to show effects of climate warming and other global changes (Stirling and Derocher 1993).

In 1973 the five nations within whose boundaries polar bears occur negotiated the International Agreement on Conservation of Polar Bears. The agreement, ratified in 1976, prohibited the taking of polar bears by hunters in aircraft or large motor vessels, creating a de facto sanctuary in active offshore ice habitats. The agreement required each nation to conduct a research program and coordinate management and research, with other jurisdictions, for populations that overlap international boundaries.

In the United States, the agreement was implemented by enactment of the Marine Mammal Protection Act of 1972. Under the act, only Native people living along the Alaska coast were allowed to take polar bears. The act, however, removed restrictions on the take of cubs and females with cubs and the mandatory reporting requirement of the state's management program. Despite elimination of many management tools, the act required the Department of the Interior to manage polar bears within the bounds of optimum sustainable population levels.

Counting Polar Bears

We captured polar bears and marked them with ear tags and tattoos. Selected adult female polar bears also were fitted with radio collars. Captured bears were weighed and measured, and a vestigial premolar tooth was removed for age determination (Stirling et al. 1975; Hensel and Sorensen 1980). Each year, we tallied new captures and recaptures, and updated capture and reproductive histories of previously marked animals. We constructed life tables from the capture data (Seber 1973; Caughley 1977), and estimated survival rates from radio-collared bears and their young (Kaplan-Meier method; Pollock et al. 1989). We examined patterns of population size with matrix models (Leslie 1945, 1948).

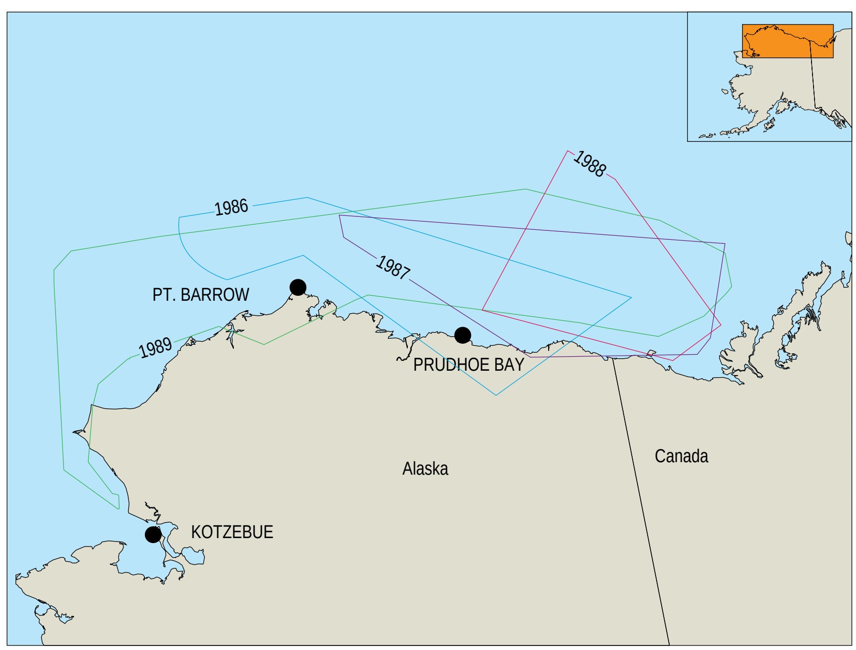

Fig. 1. Outlines of the annual activity areas for one radio-collared polar bear (*Ursus maritimus*) monitored during 4 consecutive years. The boundaries of the multiyear activity area enclosed 517,000 km^2 (about 200,000 mi^2).

Population Estimates

Recaptures were too few in the Chukchi Sea to evaluate population status for that subpopulation. Many data were available from the

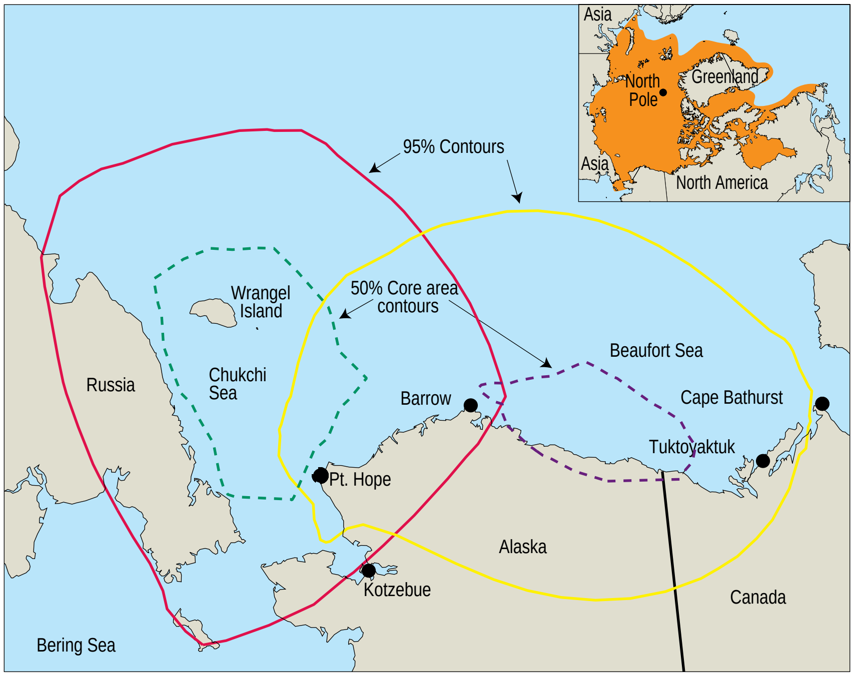

Fig. 2. Approximate bounds of the Beaufort Sea and Chukchi Sea polar bear populations. The contours for each population surround 95% and 50% of the radio relocations that were nearest the harmonic mean center of the distribution of relocations.

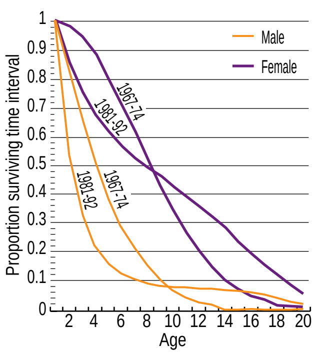

Fig. 3. Curves comparing survival of male and female polar bears in early (1967-74) and late (1981-92) periods. Note poorer survival of young and improved survival of adults, indicative of a relatively large population, in later period.

Beaufort Sea, however. We compared 986 captures and recaptures from the 1967-74 period to 1,531 captures and recaptures from the 1981-92 period to evaluate population trends. Reproduction among females commonly began at age 6 and continued until at least age 24. Numbers of cubs produced per female in both time periods were similar, but litter sizes of yearlings were larger in the first period. Differences in sampling during the two periods may have prevented effective comparisons of birth rates and of litter sizes; the age structure of the population was younger in the first period. Survival of adults, as calculated from life tables, was higher and survival of young lower in the 1981-92 period (Fig. 3). Radio-collared bears had a survival rate of 0.965 (96.5% survived), and their dependent young survived at the rate of 0.676 (67.6% survived). Of 26 radio-collared females followed until death, 22 (84%) were shot by coastal hunters.

We used a modified Petersen mark-and-recapture model (Seber 1973) to estimate there were approximately 600 females in the Beaufort Sea in 1976. Placing our calculated birth and death rates into matrix models projected growth to 900 females and 1,500 total animals in 1992. This was a realized growth rate of about 2% per year. The modified Petersen model provided an estimate of 750 females for 1986. That growth rate projected forward to 1992 indicated 850 females and just over 1,400 total animals; numbers that agreed closely with those predicted by the matrix models.

Numbers of bears captured per unit of effort, in the Beaufort Sea, also have increased, providing another indication of population growth. The few catch/effort data from the Chukchi Sea also suggest an increasing trend. There was a compensatory relationship between estimated population size in the Beaufort Sea and recruitment of subadults. Large populations of recent years recruited few juveniles, and smaller populations present in the first period recruited higher proportions of juveniles.

Implications of Growth

We are confident that the growth we detected in the Beaufort Sea population is real. A finite rate of growth of 1%-2% and a current population of approximately 1,500 are both reasonable. Increased numbers of polar bears seen along Alaska's north coast in recent years, increased encounter rates by researchers, and matrix models all suggest the population is larger now than in the recent past. This increase in numbers has occurred despite continued hunting by local resident Native people, and despite development of the nation's largest oilfield at Prudhoe Bay. The age structure and survivorship patterns of recent years suggest the population in the Beaufort Sea may be at or near the limits set by its environment.

Unfortunately, known and unknown biases in our mark and recapture data resulted in population size estimates that were associated with considerable uncertainty. The degree of fluctuation we observed in population estimates derived by the sophisticated Jolly-Seber model were biologically impossible. The estimates were more consistent in the simpler Petersen model, substantiating the observation that the trend of increase is valid, but not erasing concerns about the absolute size of the population. Less-than-perfect population estimates may not be an urgent problem if harvest is kept at a level that is known to be within long-term sustained yield (e.g., near present harvest levels). Hunting, however, already accounts for 80% of calculated annual mortality, and pressures to increase harvest are always present. Estimates of the size of the population of polar bears in the Chukchi Sea are lacking, but the catch per unit of effort during research tagging there may suggest an increase, as do observations and kills by coastal residents. Uspenski and Belikov (1991) believe there are more bears in the Chukchi Sea now than in the past despite the absence of a reliable population estimate.

Thus, the good news of apparent increases in numbers is accompanied by increased challenges for management. Those challenges can only be met by a better understanding of the dynamics of the polar bear's ecosystem. In the

Chukchi Sea, there is a pressing need for development of new methods for determining numbers and trends. This need appears more urgent in view of the likelihood that the ban on polar bear hunting in Russia, in effect since 1956, will be lifted. The bounds of optimum sustainable population levels are not known in the Beaufort or Chukchi seas, and interactions between polar bears and their prey and polar bears and sea ice, which establish these levels, are not understood. If managers are to keep polar bear numbers at optimum sustainable population levels in the face of increased harvests and other local and global perturbations, they will need more accurate and precise population estimates and an understanding of the ecosystem forces that limit polar bear population size.

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Courtesy S.C. Amstrup, NBS

Radio-collared polar bear (*Ursus maritimus*) female and 3-month-old cub.

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Sea Otters in the North Pacific Ocean

by
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About 250 years ago sea otters (*Enhydra lutris)* were distributed continuously from central Baja California, north and west along the Pacific Rim to Kamchatka Peninsula in Russia, and south along the Kuril Islands to northern Japan (Kenyon 1969; Fig. 1a). Several hundred thousand sea otters may have occurred in the north Pacific region when commercial hunting began in the 18th century (Riedman and Estes 1990).

At least two attributes of the sea otter have influenced humans likely for as long as they have resided together along the coast of the north Pacific Ocean. First, sea otters rely on a dense fur, among the finest in the world, for insulation in the cold waters of the Pacific Ocean. The demand for sea otter fur led to their near extinction in the 19th century. The fur harvest, begun about 1740 and halted by international treaty in 1911, left surviving colonies, each likely numbering less than a few hundred animals, in California, south-central Alaska, and the Aleutian, Medny, and Kuril Islands (Fig. 1a). These individuals provided the nucleus for the recovery of the species. Today more than 100,000 sea otters occur throughout about 75% of their original range (Fig. 1b). Immigration has resulted in near-complete occupation of the Aleutian and Kuril archipelagos and the Alaska Peninsula. Successful translocations have resulted in viable populations in southeast Alaska, Washington, and British Columbia. Large amounts of unoccupied habitat remain along the coasts of Russia, Canada, the United States, and Mexico.

The second potential source of conflict

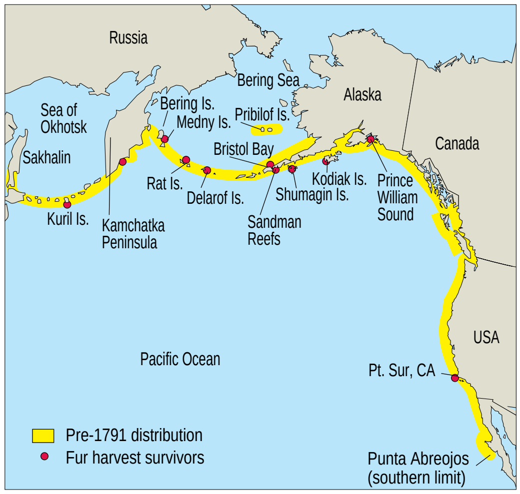

Fig. 1a. Distribution of sea otters before fur harvest began in 1741 and populations that survived the harvest, providing the nucleus for recovery of the species. Width of shaded area is not relative to sea otter habitat.

Fig. 1b. Current distribution of sea otters including locations of successful translocations.

between sea otters and humans is that sea otters prey on and often limit some benthic invertebrate populations. Because some of these invertebrates are also used by humans (Estes and VanBlaricom 1985), human perceptions about the effects of sea otter foraging on invertebrates sometimes differ. By limiting populations of herbivorous invertebrates (e.g., sea urchins [Echinoidea]) otters help maintain the integrity of kelp forest communities. At the same time, sea otter predation on other marine invertebrates can lead to direct competition with humans for resources. These interactions add complex dimensions to the conservation and management of sea otters, in large part because of wide-ranging social, ecological, and economic consequences of sea otter foraging.

Long-term data on abundance and distribution are available for relatively few sea otter populations. Here we summarize such data from three populations: Bering Island, Russia; Prince William Sound, Alaska; and Olympic Peninsula, Washington. The Bering Island population resulted from natural emigration and represents complete recovery. Prince William Sound represents near recovery of a remnant population, whereas the Washington population was established via translocations from Alaska and is just beginning to recover. We will compare growth rates and current status among these populations. Because of its unique status and growth characteristics, the California sea otter is not treated in this article.

Population Surveys

Annual skiff surveys were conducted at Bering Island from 1979 to 1993 (except 1990; Burdin et al. in press). Surveys from skiffs, airplanes, and helicopters were conducted in 1950, 1959, 1972, and 1984-85 in Prince William Sound (Johnson 1987; Irons et al. 1988). In Washington, skiff surveys augmented with ground counts were conducted from 1977 through 1987, and aerial surveys augmented with ground counts were conducted from 1989 to 1993 (Jameson et al. 1986; Jameson 1993). Instantaneous growth rates were calculated by regressing the natural logs of survey counts over time.

Population Status

Bering Island

Bering Island was recolonized by sea otters from nearby Medny Island about 1970. Growth occurred by progressive expansion around the island, with complete occupation of available habitat by 1983. The abundance of sea otters increased at an average of 22% per year, from 500 sea otters in 1979 to an estimated 3,835 in 1990 (Fig. 2). More than 20% of the population died at Bering Island during the winter of 1990-91 (Burdin et al. in press), suggesting that the number of sea otters exceeded available food resources. Little opportunity exists for emigration as the nearest unoccupied habitat is several hundred kilometers from Bering Island.

Prince William Sound

Although no surveys were conducted before 1959, at least 150 sea otters were observed in southwestern Prince William Sound in 1951 (Lensink 1962). Sea otters had spread throughout all available habitat in the sound by 1985, although growth was still apparent in the eastern part of the region (Johnson 1987). The overall growth rate in Prince William Sound between 1911 and 1985 was on average about 8% per year (Fig. 2). No density-dependent mortality event, such as observed at Bering Island, has been documented for Prince William Sound. Limited unoccupied habitat that could provide space for dispersing animals is still available both to the east and west of Prince William Sound.

Washington

In 1969 and 1970, 59 sea otters were released along the outer coast of Washington. Mortality was high, with 16 carcasses recovered after the first release (Jameson et al. 1982). Between 1977 and 1993, the population grew at an average of about 20% per year. Between 1989 and 1993, however, the average annual growth rate has been lower (12%). Unoccupied habitat currently occurs north, south, and within the present range, and continued growth is likely.

Predicted Trends

Sea otters illustrate the healthy recovery of a species following protection and active management. Rates of increase in most populations with unoccupied habitat available to them have been 17%-20% per year (Estes 1990a). As unoccupied habitats become limiting, however, density-dependent mechanisms may dramatically reduce sea otter abundance. As geographically separate populations reach equilibrium densities or as populations become so large as to create long dispersal distances to unoccupied habitats, we anticipate declining growth rates, increased mortality, and numbers of otters stabilizing near an equilibrium density. The observed trend in virtually all persisting populations since 1911 has been one of growth, with declines observed only as populations exceeded available resources (Estes 1990a, 1990b). Continued growth is expected, particularly in Washington and southeast Alaska and along the Kamchatka Peninsula.

The long-term exponential growth in many sea otter populations has allowed us to describe the process of sea otter recovery. However, as populations attain equilibrium densities and growth rates decline, evaluation of future trends will become more difficult. In addition, possible short-term changes, such as those resulting from human impacts, may remain difficult to detect. Thus, describing future population trends will require improved population- or individual-based assessment models.

At least two issues are currently relevant to sea otter conservation and management. One is competition between sea otters and humans for shellfish resources. As otters continue to reoccupy former habitat, the commercial, recreational, and subsistence harvest of species such as crabs (Crustacea), clams (Bivalvia), abalone (Gastropoda), and urchins, can be expected to decline.

Another current issue is the extent of the legal and illegal harvest for sea otter fur. Both the legal harvest by Alaska Natives and an illegal harvest in Russia have recently increased (A. Burdin, Russian Academy of Science, personal communication). Reasonable harvest guidelines and adequate inventory and monitoring programs should be established in areas with harvested populations.

Neither of these conservation issues currently appears to be precluding the continued growth of sea otter populations, but the potential to overharvest this species has been well demonstrated. Conservative management should ensure continued growth through complete recovery.

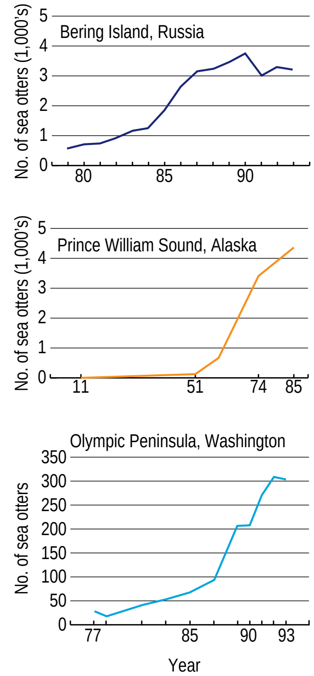

Fig. 2. Growth patterns observed in three sea otter populations in the north Pacific resulting from natural range expansion (Bering Island and Prince William Sound) or translocation (Washington).

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Courtesy NBS

Sea otter (*Enhydra lutris*).

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Pacific Walruses

by
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Pacific walruses (*Odobenus rosmarus divergens*) live in the Bering and Chukchi seas of Alaska and Russia (Figure). The population is subject to a Native subsistence harvest in Alaska and a commercial and subsistence harvest in Russia. Total annual harvest ranges between 5,500 and 10,300 walruses (Fay et al. 1989). The Marine Mammal Protection Act requires management of the population within an optimal sustainable population range, and the subsistence harvest by Alaskan Natives cannot be regulated unless the population is declared depleted.

Pacific walruses are an important source of meat and ivory for Native peoples of Alaska and the Chukotka Peninsula, Russia. The species is long-lived, has a relatively low reproductive rate, and occupies a position near the top of the marine food chain. Thus, besides being a very visible species, the walrus may be an indicator of the health of the Arctic marine ecosystem. The United States and the former Soviet Union initiated cooperative surveys throughout the entire range of the shared population in 1975 and have since conducted periodic surveys at 5-year intervals.

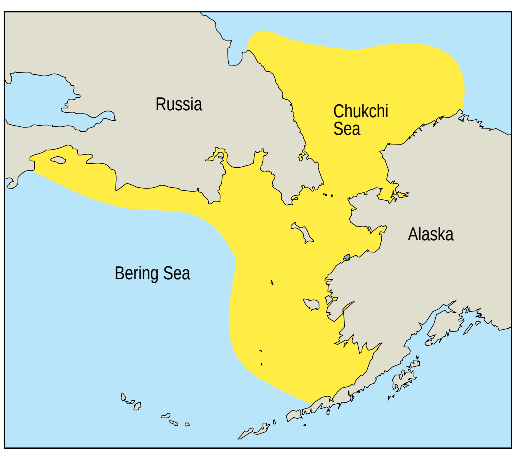

Figure. Distribution of Pacific walruses in the Bering and Chukchi seas of Alaska and Russia (Fay 1982).

U.S.-Russian Walrus Surveys

Walruses are gregarious and often form large groups when resting on sea ice or land. This behavior is called “hauling-out,” and land sites where large groups traditionally congregate to rest are commonly called “haul-outs.” The cooperative U.S.-Russian surveys used aerial counts of walruses on sea ice in the Russian and U.S. sectors, aerial and photographic counts at Russian land haul-outs, and ground and aerial counts at U.S. land haul-outs (Estes and Gilbert 1978; Estes and Gol’tsev 1984). Aerial surveys were conducted in the U.S. sector during 1975, 1980, and 1985, and were extended to include sea ice within the Russian sector during 1990 (Gilbert et al. 1992). Biologists altered each subsequent aerial survey to increase the precision of the estimates (Johnson et al. 1982; Gilbert 1986, 1989; Hills and Gilbert 1994).

Because of the ongoing efforts to improve the surveys, specific techniques varied among years but the basic design was to fly a series of north-south transects beginning at the edge of the polar ice pack and ending where concentration of ice was sufficient to exclude walruses. Transects were arranged systematically and stratified to achieve maximum coverage of the Chukchi Sea. Transects were located approximately between Pt. Barrow, Alaska, and the international border in 1975, 1980, and 1985, and throughout the entire Chukchi Sea during 1990. Most land haul-outs also were surveyed from aircraft, either by counts made directly by observers or from photographs. Some haul-outs were visited and counted by observers on the ground.

Biases were evident in the survey data, and lack of precision was common in all surveys (Estes and Gilbert 1978; Johnson et al. 1982; Gilbert 1989; Gilbert et al. 1992). Surveys, however, were continued because biologists believed that, despite these faults, the surveys would indicate population trends and were the best available method for assessing population size (Johnson et al. 1982; Gilbert 1986). Also, researchers recognized that an unknown and variable part of the walrus population was not available for counting because the number of walruses that were hauled out on land or ice varied significantly from day to day (Estes and Gilbert 1978; Gilbert 1989; Gilbert et al. 1992). None of these surveys used a correction factor for this unobserved fraction, and no attempts were made to classify walruses by age or sex. Even though population trends cannot yet be reliably determined by these surveys, researchers believe that long-term data from the surveys will eventually provide more definitive information about the status and trends of walrus populations.

Walrus Population Estimates

The point estimates for walrus population size were 221,000 for 1975, 246,000 for 1980, 234,000 for 1985, and 201,000 for 1990. Even though confidence intervals of these estimates were large, these estimates are considered the best information available to assess the status and trends of the Pacific walrus (Hills and Gilbert 1994). Estimates from sea ice exceeded those from land haul-outs except during 1990, when the ice pack receded much farther north and over deeper water than in most years. Because most of the large land haul-outs were in Russia, estimates there are higher than in the United States. Although these data indicate a general decline in numbers of walrus between 1975 and 1990, some biologists question the validity of this apparent decline (Hills and Gilbert 1994). Other researchers believe the population may be declining, based on various biological indices (Fay et al. 1989).

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Mentasta Caribou Herd

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The Mentasta caribou (*Rangifer tarandus)* herd, a small herd that lives in and around Wrangell-St. Elias National Park and Preserve, Alaska, experiences population trends and management problems that are typical of many mountain herds in central Alaska and the Yukon Territory of Canada. Traditionally, the herd has been important for sport and subsistence hunting, but a recent decline in numbers led to suspension of hunting in 1992. The Alaska National Interest Lands Conservation Act authorizes the National Park Service to allow subsistence hunting throughout Wrangell-St. Elias, and sport hunting on preserve lands, provided that hunting is consistent with sound wildlife management principles and conservation of natural and healthy populations. Even though the National Park Service allows hunting, other agency mandates do not allow predator control or habitat management to enhance declining populations for hunting.

Sound information on caribou populations, gathered every year, is used to determine when hunting seasons are allowed and how many caribou can be taken by hunters. The collection of reliable data will help minimize conflicts between the dual objectives of providing hunting opportunities and maintaining natural characteristics of wildlife populations. Information on wildlife populations in national parks also provides important insights on natural population fluctuations for comparison with more actively managed wildlife on adjacent lands.

Biologists have monitored population size and composition of the Mentasta herd routinely since 1973 to provide basic information for management. They expanded monitoring and research in 1992 to improve their understanding of population-limiting factors during a period of rapid population decline.

Surveys of the Caribou Herd

Biologists have estimated the size of the Mentasta herd nearly each year since 1973 from aerial surveys conducted after the calving season. During late June, caribou congregate in high-mountain habitats or snow fields, where they are most readily visible from airplanes, and are counted by biologists.

Biologists also determine the population composition of the herd twice annually: after calving season in late June and during breeding season in early October. They classify caribou as calves, cows, or bulls. The counts in late June provide an index of early calf survival; counts in early October provide an index of summer survival of calves and proportions of bulls in the population.

In 1992 and 1993, biologists determined birth rates of cows to see whether low calf-to-cow ratios in late June resulted from low productivity. They determined birth rates by inspecting cows at close range from a helicopter

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during the peak of calving; observers looked for presence of calves or swollen udders, indicating cows had or would soon produce calves.

In 1993 biologists measured survival rates of calves and adult cows to help interpret causes of the rapid population decline observed in the early 1990's. They measured survival rates by fitting 39 calves and 41 adult cows with radio-collars containing mortality sensors. They located these radio-collared caribou daily during the calving season in 1993, weekly during the remainder of summer, and once every 2 months throughout winter. When biologists located carcasses of dead caribou, they inspected them as soon as possible to determine the cause of death.

Population Trends

The Mentasta herd increased from about 2,000 caribou in the early 1970's to 3,200 in the early 1980's, an increase of about 5% per year (Fig. 1). Since 1989 the Mentasta herd has decreased to a low of around 900 caribou in 1993, a decrease of about 24% per year. Between 1992 and 1993 alone, the herd decreased by one-third.

This population decline appears related, in part, to changes in calf survival or production between the 1980's and 1990's. The proportion of cows with calves in late June declined from 39 calves to every 100 cows in the late 1970's and early 1980's (including a high of about 50 calves to 100 cows in 1979), to only 6 calves to every 100 cows in the early 1990's (Fig. 2). Similarly, estimates of calf-to-cow ratios in October have decreased about 90% since the 1980's.

Recent surveys of birth rates indicate that rapid declines in calf-to-cow ratios were not related to poor productivity of cows. In 1992 an estimated 81% of cows produced calves; in 1993, 70% did. Although birth rates were below average in 1993, productivity was sufficient for the herd to grow in the absence of high calf losses.

By intensively radio tracking newborn calves, biologists showed that the low calf-to-cow ratios were related to high death rates of calves. Of 39 calves radio-collared at birth, only 1 (2.5%) survived the summer. The rest were lost to predation by gray wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), and wolverines (*Gulo gulo*), or they died from unknown causes.

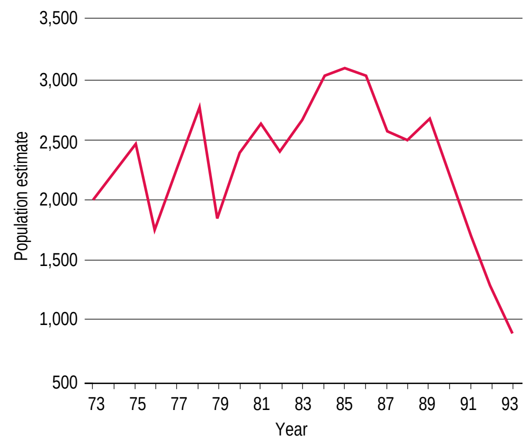

Fig. 1. Recent trends in size of the Mentasta caribou herd, 1973-93.

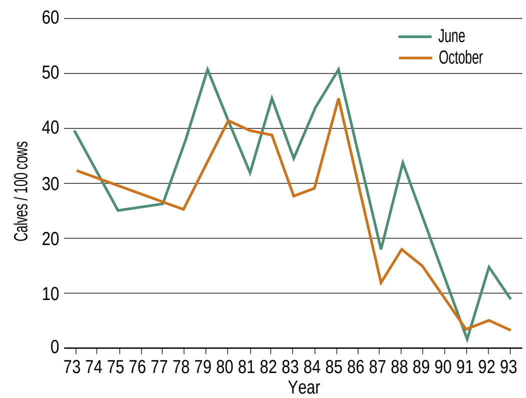

Fig. 2. Recent trends in calf production (June) and number of calves (October) in the Mentasta caribou herd, 1973-93.

Survival rates of adult cows also were low. Of 41 cows radio-collared at the beginning of the study, only 83% (34 cows) survived 1 year. By contrast, generally 88%-96% of adult cows survive each year in stable or increasing herds.

Ongoing monitoring will increase understanding of natural fluctuations of the herd and provide information for incorporating fluctuations into a scheme for determining harvest quotas. Currently, biologists propose to allow annual harvests equal to a small percentage of the number of calves in the herd each fall, a good index of population trends. This proposal will link the harvest to patterns of herd growth and incorporate the objectives of natural populations and resource use into one workable management model.

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Tundra or Arctic Hares

by
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The tundra or Arctic hare (*Lepus othus*; systematic studies are being conducted because some researchers classify the hare as *Lepus timidus*) now has a restricted distribution in western Alaska (Figure). It occurs in tundra habitats and also in shrub communities along streams. Its primary foods are willows, grasses, and herbaceous plants. Indigenous people, particularly in the coastal tundra of the Yukon-Kuskokwim Delta regions, the Seward Peninsula, and the Kotzebue Sound drainages, have a long history of using the tundra hare for food and clothing. The hare has declined in number throughout much of its range; biologists do not know what has caused its reduced distribution or the decrease in numbers.

Distribution Records

We obtained information on the former and present distribution and numbers of the tundra hare from historical records and reports and from interviews of state and federal wildlife biologists and local residents (Bee and Hall 1956; Murie 1959; Anderson 1974). Biologists conducted limited reconnaissance surveys on the Alaska Peninsula during 1990 and 1991, in the Yukon-Kuskokwim Delta region in 1973, and on the Seward Peninsula and in the Kotzebue region during 1985, 1986, and 1993. Field surveys continue on the Seward Peninsula and near Kotzebue, along with studies of the habitat requirements of these hares. A mail survey to determine population status throughout their distribution is being initiated through the University of Alaska-Fairbanks.

Status

Historically, the tundra hare was present in the Alaskan Arctic north of the Brooks Range (the "North Slope") from the Colville River westward (Bee and Hall 1956), but there have been no records of hares in that region since 1951 (Figure). Circumstantial evidence suggests that the tundra hare may have declined after the arrival of the snowshoe hare (*Lepus americanus*), which was not present there early in this century. The relationship may be direct through food or parasites and disease, or indirect through increased numbers of predators during snowshoe hare population highs.

The northern limit of tundra hare distribution in the coastal area of western Alaska has shrunk southward, and the hare is now absent or extremely rare north of Kotzebue. Centers of abundance are the western Seward Peninsula and the Yukon-Kuskokwim Delta region, although numbers have remained low there since population highs in the 1970's. Throughout its southern distribution on the Alaska Peninsula, tundra hare densities are currently low; high densities were last reported there in the winter of 1953-54 (Schiller and Rausch 1956). Researchers at the University of Alaska-Fairbanks are attempting to explain reasons for the tundra hare's decline.

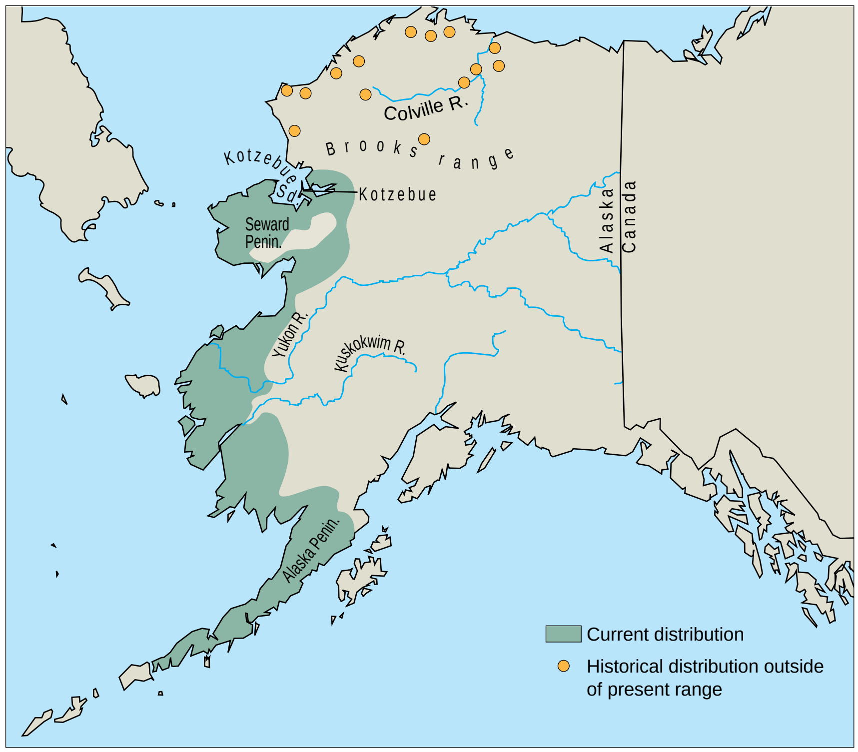

Figure. Distribution of the tundra hare, with historical records of occurrence outside of its present distribution.

Tundra hare (*Lepus othus*).

References

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